INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

ANNUAL REPORT—1937

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The following is a report of the work of the Station during 1937.

Messrs. Cooper and Tunstall were on home leave for periods of seven and four months respectively. No addition to our senior staff took place and under the circumstances it was impossible to undertake any touring beyond that necessitated for attending the various Annual General Meetings of the Assam Valley and Surma Valley Branches of the Indian Tea Association, the Dooars Planters' Association, the Terai Planters' Association, the Darjeeling Planters' Association and the Indian Tea Association, Calcutta. These meetings were attended in accordance with the usual custom.

I now will discuss the experimental work in the same order to which it is referred in the 1937 Programme of Work.

In previous years experiments were made to find out the effect that varying degrees of fineness of plucking had upon the quality of the tea made. In general the finer the leaf plucked the better was the quality, although the differences were small between superfine plucking consisting chiefly of one and a bud, and fine plucking to medium plucking consisting entirely or almost entirely of 2 leaves and a bud. The different pluckings were all taken over 8" of new growth and then to the *janum*. A further obvious experiment is an alteration in the initial lengths of growth. This experiment was carried on throughout the year and is an extension of work done during 1935.

The season's manufacture can be divided into three parts :—

(1). The late second flush and early rains ... 4th June to 30th July.
(2). The rains period ... 6th August to 24th Sept.
(3). The autumnal period ... 1st October to 30th Nov.

Owing to the climatic conditions it was impossible to obtain sufficient leaf for manufacture before the beginning of June and consequently no comparisons could be made of early second flush teas.

Of the late second flush teas there is no significant difference between any of the valuations for the 8 different teas nor is there any difference in regard to tip, colour of infused leaf, liquor strength, quality and briskness. In the late second flush therefore, the form of plucking giving the greatest crop has given the best return.

During the rains period the Calcutta tasters find that the leaf plucked over a serrated leaf left only at the second round of plucking gives better tea than plucking over 4" and 6" of new growth to the *janum* but no significant difference in the case of the 8" length. The London tasters show no significant differences but their order of merit confirms the Calcutta tasters' opinion. The Calcutta tasters indicate slightly better quality of liquor in the rains tea from bushes plucked over a leaf in the second round of plucking compared with bushes plucked throughout to the *janum*. There are no indications of any differences due to the different initial lengths of growth.

In the autumnal period both the Calcutta and the London tasters show a significant preference for teas plucked over a serrated leaf on the second round of plucking compared with teas plucked throughout to the *janum*. In this period also the longer the initial growth the better were the teas. In this case also an improvement in quality is noticed and also in tip, colour of infusions, liquor, and briskness. The Calcutta tasters

showed a preference for the autumnal tea made from bushes plucked to a short length of 4″ of new growth and then to the *janum* up to August then raising the plucking height by 2 serrated leaves at the centre of the plucking surface, compared with all other forms of plucking except 8″ of new growth and a serrated leaf at the second round of plucking.

The tea bushes for the experiment to which I have just referred were pruned in December. The pruning of a garden must however extend over a considerable period of time and consequently it is of importance to know whether top pruning at different times of the year has any effect upon not only the crop but also the quality of the tea made. The results of an experiment carried out during the year are as follows.

The pruning was done during six different months so that teas were made from bushes pruned more than 12 months previously.

During the early part of the year in the time of the early second flush owing to the climatic conditions to which I have already referred it was not possible to manufacture the tea from December or later pruning but the tea from the previous April, June and October was manufactured from the 18th May to 15th June. Both the London and Calcutta tasters preferred the tea from the October pruning. This preference was greatest at the first manufacture and the difference became less by the middle of June.

From the 22nd June until the 16th November all the different pruning treatments were manufactured. Pruning in December and January has given over the whole period the best results. Tea pruned before that time has given poorer results and tea pruned at a later date (in February) also has given slightly poorer results. The differences for the cold weather pruning are small and it would seem from this first experiment that pruning at any time during the cold weather between October and February makes little difference to the quality of the tea made for any particular date of manufacture or for an average throughout the

season. This is of importance as it permits of distributing the pruning over a long period of time. In a previous year it was found that tea made from leaf plucked from bushes more than 12 months from pruning was not as good as tea from leaf plucked from bushes less than 12 months from pruning, when the pruning was done in December. The present data support the previous findings.

In the case of the teas made in connection with the experiments to which I have referred, a difference was noticed in the amount of "creaming" of the liquors and an estimation was made of these differences. It was found that tea from clean-pruned bushes creams down more than tea from bushes annually cut across. It will be noticed that this corresponds with the better valuation but it is not suggested that the creaming down has been the cause of the increased value. It is however of interest to note that it is coincident with it. It was also noticed that the shorter the initial growth left on the bush before tipping the greater is the creaming down of the teas made, and also that tea from bushes plucked to the *janum* gives liquors which cream down better than tea from leaf plucked over one big leaf at the second round of plucking. This applies to late second flush teas and those made during the rains period. It was also noticed in "the time of pruning" experiment that for the same day of manufacture the teas from bushes longer from the time of pruning creamed down more. In the case of these experiments all the teas creamed well and it has not been possible to associate the degree of creaming with an improved valuation.

At the present time with the Restriction Scheme in force and gardens able to make easily their alloted crop quota, it is of some importance to know whether there is any advantage in pruning at any particular time of the year, and this year's experiments indicate that the pruning in the cold weather between the months of October and February does not make any marked difference in the quality of the teas made during the late second flush and the rains period. It has however hoped that

we might have some information in regard to the comparative quality of the teas made during the earlier part of the year. Owing however to the peculiar climatic conditions this was not possible as only some of the pruning treatments gave sufficient leaf for manufacture before the middle of June. So far then as this experiment allows tentative conclusions to be drawn it seems that the October pruning has given teas not appreciably inferior to the teas pruned in the following December and it has given increased crop of ½ md. per acre up to the end of the second flush. This suggests that there may be a possibility of increasing the amount of early teas without appreciably altering the quality. It would however be unwise to draw any definite conclusions from one year's experiments. It will be necessary to repeat this experiment in other years. It cannot be carried out again in 1938 because the pruning will not then be in a similar stage. A detailed account of the manufacturing experiments is given in Appendix A.

In 1936 a preliminary experiment was made with the manufacture of tea plucked from individual bushes. It was noticed that there was a considerable variation in the quality of the tea made. This investigation was to be expanded in 1937 by manufacturing the leaf from 200 bushes belonging to the same jat. Unfortunately the miniature C. T. C. machine that we had expected to receive in the early part of the year did not arrive and indeed has not yet arrived. We therefore had to devise some other method for manufacture. I am glad to say that we were able to find a fairly satisfactory hand-method which has made it possible to carry out the programme and in addition to manufacture tea from an additional 108 bushes; in all then tea has been manufactured from 308 different bushes with replication during the year. The results very clearly show that the individual bushes belonging to a jat of tea noted for its evenness give teas varying greatly in characteristics. This investigation has been made with the object of using bushes having desirable characteristics for establishment of clones. Data are given in appendix B to show the variations found.

In the experiments comparing teas of different jats it was noticed that the fermentation proceeded differently for the different jats, and it was decided to investigate this. During the year however we have been able to do no more than study technique. We have not yet found a satisfactory method for measuring differences in the fermentation of the different teas.

The tea industry has generally accepted that a cool temperature or fermentation is advisable but this was based on general experience without reliable data. In 1935 and 1936 experiments were carried out to ascertain whether temperature during fermentation did influence the quality of the tea and this investigation was enlarged during 1937. I am glad to be able to state that although we have not had the miniature C. T. C. machine, we have been able to carry out a great deal of the work but under conditions that unfortunately were not as good as they would have been if we had had the machine.

The leaf for the experiment had to be rolled in the ordinary manner. During one hour of rolling the leaf becomes heated to a greater or lesser degree. Fermentation at controlled temperature follows. The results clearly indicate the improved teas made with fermentation at the lowest temperature, that is, 70°F. and the very rapid falling off in quality and other characters of the teas as the fermentation temperature rises to 100°F. This laboratory finding has received confirmation in the course of experimental factory manufactures at Tocklai as shown by the correlation existing between the temperatures in the factory during manufacture and the valuations and reports of the teas made. We have, however, not been able to ascertain whether the rise in temperature during rolling had much effect. It is possible that if the tea could have been kept at the low temperatures during the whole time of manufacture even better teas would have been made. This requires investigation. We hope that by using the miniature C. T. C. machine we shall be able to eliminate the necessity for rolling the leaf for any length of time and consequently eliminate the rise in temperature that is associated with rolling.

The effect of temperature upon the different characters of the tea is of much interest. For instance tea fermented at 70°F. had a very bright coloured liquor for all the manufactures throughout the year whereas tea manufactured at higher temperatures showed a falling off with the lengthening of the time of fermentation and also with the different dates of manufacture. Other characters such as quality also showed a loss with rise of temperature.

It will be necessary to still further enlarge the scope of this experiment. The rise in temperature during rolling must be avoided and we must also experiment with still lower temperatures.

The results up-to-date are of interest in providing data confirming the general opinion of the industry that fermenting rooms should be kept cool. So far as these experiments go they indicate the desirability of keeping the temperature as low as it is possible to do by the use of humidifying arrangements. The use of efficient mist chambers should enable a tea house suitably constructed to maintain a temperature between 80°F. and 82°F. in the rolling and fermenting rooms. Unfortunately many factories are so built that it is difficult to obtain these temperatures. Whilst these results are of interest and suggest some practical application yet they cannot be accepted as providing any final conclusion. The investigation must be continued.

Cleanliness of the surface of the bed on which fermentation is done is an important matter and the choice of suitable materials for the beds depends much upon the ease of cleaning. During the year it has been possible to carry out experiments throughout 16 weeks from July to November manufacturing teas made by fermentation on a clean cement floor and on a polished aluminium surface. In no instance did the tasters' reports or valuations show any significant difference.

At this point it is of interest to record that this year for the first time we adopted a definite glossary of terms for tasting

the experimental teas. The different characters that we wished to study were defined by the tasting terms in general use but each of these terms was sub-divided qualitatively so that it was possible to compare teas in regard to briskness or quality or other characteristics for which the tea was examined. This system of tasting was readily accepted by tea tasters both in Calcutta and London and the results have been of great value for it has enabled us to understand how the different characters may be influenced by treatment and also to understand how these characters may influence the final decision of the taster as indicated by his valuation. I wish to express my thanks for the assistance we have received from the various tea brokers—5 in Calcutta and 8 in London—who have gratuitously tasted a large number of experimental teas. Without their help it would have been impossible to carry out these experiments. Recently we have received intimation that other tea brokers in London who have not been in the past in our team are willing to help us in the future and during the coming year we hope to make use of the services of 11 tasters in London as well as 5 in Calcutta. This is a great gain as it enables us to carry out more experiments, for a limiting factor has been the number of teas that we have been able to send to any one taster in a week. The experimental teas call for very critical tasting; they have to be infused probably several times, and their examination does take a considerable amount of the taster's time. Our thanks also are due to the Jorehaut Tea Company Ltd., for permitting us to make use of their tea taster Mr. R. Gilchrist who not only tasted teas made in the ordinary course of experimental manufacture but, who, in addition tasted all the teas made from individual bushes. It was only possible to send such teas to one taster since the amount manufactured at one plucking from one bush was of such a small amount as only to allow of sometimes one infusion.

The survey of moulds in finished tea has been continued and further data accumulated. At present this investigation

is almost entirely concerned with accumulating data. It will be some time before we have sufficient to permit of a discussion of the results.

In the 1937 Programme of Work reference was made to the infection by pathogenic organisms of unhealed wounds being responsible for the death of a large number of bushes. It is in this connection that we have an experiment in progress to find out conditions that affect the rate of healing of a newly made cut. Bitumen mixed with Kerosene so as to make it possible to apply with a stiff brush appears to be the most satisfactory of the treatments we have tried. The length of new growth left before plucking influences the healing. In the second year healing was more nearly complete on bushes that were plucked at 12″ as compared with those plucked at 6″ of new growth. Leaving a bush unplucked did not show a greater healing than bushes plucked at 12″ of new wood. Plucking to the janum without breaking back over 6″ and 12″ of new growth shows an increased tendency to healing but this is not noticeable on longer lengths of growth. The results up-to-date suggest that whilst healing of cuts will not take place in one year a longer length of growth is helpful yet this need not be unduly long and in some cases need not extend to much beyond 12″ if the subsequent plucking is done without breaking back. The not breaking back seems to be more important than leaving a leaf at the second round of plucking.

A lot of work remains to be done in this direction for we have not yet found a wound dressing that applied at the time of cutting will keep the wound until healed free from disease organisms without further treatment.

For several years we have been carrying on an investigation dealing with the starch reserves in the roots of the tea bush. A large amount of data had been collected but the interpretation was only possible by statistical analysis which involves a great deal of work.

We were fortunate in being able to get the help of Mr. S. S. Bose of the Statistical Laboratory of the University of Calcutta who came to Tocklai for two months.

The results show that the amount of starch steadily increases as the season advances from spring to winter. The rate of increase is however not the same for bushes receiving different treatmeuts. In the case of the untreated bushes a significant correlation of an inverse order is found between the starch and the yield. Meteorological factors were also considered; the only significant correlation was a positive one between starch and the total hours of sunshine. The yield did uot show this correlation but gave a positive correlation with the daily maximum temperature.

At the beginning of 1935 a development study, (as defined by the Commission of Enquiry) was commenced dealing with the flowering of the tea bush. The flowers develop only at the *janum* axils. The mode of coming away into a flush period which is recognised for leaves also applies to flowers. Whilst a flower bud develops during one flush period it is not until the bush starts the next flush period that the flowers open. There are two flowering periods of a tea bush—one from the middle of the third flush to the advent of the first flush of the succeeding season, and the other from the beginning of the second flush to the end of the same flush. The flowers which open from the middle of the third flush to the advent of the first flush of the succeeding season are generally from the first to third flush growths of the shoots. The flowers on the third flush *janum* axils open at about the end of the fourth flush and the flowers on the fourth flush *janum* axils open during the winter growth period and this flowering is over before the shoots come away for the new first flush.

A summary of this work is given in appendix C. It is hoped to publish soon a more detailed account of this very interesting investigation.

The name by which the tea plant has been known has varied frequently. The International Horticultural Conference

held in Paris in 1932 has included tea amongst the Camellia and we shall therefore adopt this nomenclature for the future.

During 1937 we have been unable to initiate any new field experiments at Tocklai because we had not the necessary permission to plant out land that had not been previously under tea.

The various field experiments at Tocklai, Tulsipara and on estates are being continued and generally call for no special comment.

Some results have been obtained from the treatment of young tea however to which I should like to call attention. In the cold weather of 1935-36 tea one-year old from seed was planted out. At the time of lifting from the nursery the plants were cut to a height of 8″ from the ground. The manurial treatment was commenced in the spring of 1936 and has been continued. At the end of 1937 the tea was cut across at 18″ from the ground and the prunings weighed. This weight was taken to indicate the growth of the bushes. Manuring with 60 lbs. of nitrogen per acre in the form of Sulphate of ammonia significantly depressed the growth of the plants. The plants manured with 20 lbs. of nitrogen per acre were noticeably better than tea that had no application of nitrogen. It seems that for such young plants too great an application of nitrogen can be given. I particularly call attention to this as I think there is sometimes a tendency to be over-generous in the application of nitrogenous manures to young tea. I suggest that for tea as young as in this experiment the application should not exceed 40 lbs. of nitrogen per acre unless there is definite information showing that for any particular garden a heavier dose is suitable. The same experiment at Tocklai showed an improved growth by the use of potash. This is of interest because the application of potash for a number of years to mature tea has had very little effect at Borbhetta.

Another experiment with young tea was made to ascertain what would be the result of pruning at different heights at

different times of the year. Three different heights were adopted namely

(*a*) 0″ to 2″ from the ground
(*b*) 8″ to 10″ from the ground
(*c*) 16″ to 18″ from the ground.

The times of pruning were February and June. The number of deaths associated with the different times of pruning are as follows :—

Pruning height.	Times of pruning	
	February.	June.
0″ to 2″	16%	26%
8″ to 10″	0.9%	2.7%
16″ to 18″	0.8%	1.4%

When discussing last year the Programme of Work for 1937 I said that we hoped to have the results from experiments with the use of vegetable compost. Six experiments are being carried out on estates and there are two at Tocklai. The results of the first year show a small crop increase in two cases, in the remainder there is no significant effect from the use of compost. It is to be noted that the use of the unfermented vegetable matter has given a better result than has been obtained from the same quantity of material composted. It will of course be necessary to continue these experiments for some years in order to find out what may be the value of such manures when applied over a long period of time. In Appendix D Mr. Cooper discusses bulk organic manures. I wish to suggest that it would be wise for estates not to incur any great expenditure in the preparation and application of composts until further reliable data are obtained.

There are a number of field experiments that are being carried out on various tea estates to ascertain the value of nitrogen, phosphate, and potash in the form of mineral manures

in the different districts. The indications of the first year of the experiments are interesting in that they show that on bheel soils nitrogen has given no significant increase of yield. There are indications that the use of potash on such soils is of benefit.

During November and December three Lecture Courses were held consisting of 20 members at each Course. My suggestion that there should be two Senior Courses was adopted.

During the year we had three scientific visitors :—

Dr. Eng. S. J. Wellensiek and Dr. E. R. Tubbs, PH.D. (Lond.), D.I.C., A.R.C.S., F.L.S., from the Thee Proefstation, Java and the Tea Research Institute of Ceylon respectively who were particularly welcome by reason of their interest in the selection and vegetative propagation of tea. I consider that such interchange of visits between the tea experimental stations is for the general benefit of the industry and is to be encouraged.

It gave me very much pleasure to be able to welcome to Tocklai Sir John Russell, the Director of Rothamsted Experimental Station and Lady Russell.

I have already referred to the visit of Mr. S. S. Bose to Tocklai. His visit was of great value. He was able to discuss with officers the most suitable statistics to employ and was able to give training in elementary computing to some of the Unqualified Assistants so that the officers could be relieved of a great deal of routine calculation.

Since Mr. Bose's visit we have had 4 such computors kept fully occupied.

The statistical requirements of the Station are annually increasing.

Two publications, one by Mr. Cooper dealing with Nitrogen and its relationship to crop and quality of tea, and the second by Dr. Wight dealing with the flushing of the tea bush, are both very much overdue but the manuscripts are expected to be in the hands of the printers very shortly.

APPENDIX A.

EXPERIMENTS ON THE EFFECT OF VARIOUS CULTURAL FACTORS ON THE QUALITY OF TEA.

Plucking and Quality.

Leaf from 8 series of plots plucked as follows, was manufactured weekly throughout the 1937 season.

1. Plucked to 4″ initial height and then to the *janam* throughout the season.
2. Plucked to 6″ initial height and then to the *janam* throughout the season.
3. Plucked to 8″ initial height and then to the *janam* throughout the season.
4. Plucked to 4″ initial height, then one big leaf on the second round, and then to *janam* for the rest of the season.
5. As 4, but plucked to 6″ initial height.
6. As 4, but plucked to 8″ initial height.
9. As 1, up to end of July; unplucked all August, then skiffed leaving two leaves above previous plucking level, then plucked to the *janam* for the rest of the season.
10. As 1, up to end of July, unplucked for one round, then plucked leaving two leaves over previous plucking level, then plucked to *janam* for the rest of the season.

The first six series have been plucked as above for three seasons 1935, 1936 and 1937. Series 9 and 10 were treated as above in 1936 and 1937. In 1935 both series were out of plucking during August after being previously plucked to 4″ and to *janam*. Both series were then skiffed, leaving 3 leaves

in the case of series 9, and one leaf in the case of series 10, over the previous plucking level. Both series were then plucked to the *janam* for the rest of the season.

Leaf from six out of the above eight series was manufactured during the autumnal period of 1935; reports and valuations of the teas were obtained from 5 tasters in India and 5 in London.

The crops obtained, and the average valuations given for the teas over the 1935 autumnal period, are tabulated below and may be compared with results obtained over the same period during the past season.

Crops and Valuations for different forms of plucking 1935 season.

Style of plucking	Mds. Tea per acre. October and Nov.	Average valuations for October and November.	
		Calcutta	London.
		As. P.	S. D.
4" and to janam	4·02	10—8·1	1—2·3
8" " " "	3·79	10—11·4	1—2·6
4" and one leaf	3·74	10—8·5	1—2·5
8" " " "	3·44	11—0·5	1—2·7
Unplucked 4 weeks and Skiffed to 1 leaf		10—8·1	1—2·1
Significant difference		2·4 p.	0·33 d.

The conclusions arrived at as a result of considering the Calcutta tasters' results as a whole are as follows. The leaving of a big leaf during the plucking round following the tipping has had no significant effect on quality late in the season though the tendency is for better teas to result from leaving the leaf. The extra initial growth has produced significantly better teas,

whether subsequently plucked to the *janam* or whether a leaf was left on the round following tipping. The tea manufactured from bushes skiffed leaving 3 leaves above the previous plucking level is significantly preferred to that from bushes skiffed leaving only one leaf.

From both sets of skiffed plots, practically no leaf was plucked till October 4th on which date and on October 11th very big flushes were taken. On these dates the teas from the *high* skiffed plots were very tippy, and were valued for their liquors significantly better than all other five. Teas from the low-skiffed plots on the contrary were worse than all the other five. The good quality of the high-skiffed teas was not well maintained in the later pluckings.

The London valuations for 4″ and 8″ plucking (both to the *janam*), are not significantly different, nor are the valuations for 4″ and 8″ plucking when one big leaf is left subsequently. If however the averages for 4″ plucking are compared with the 8″ plucking, the difference becomes significant.

The combined averages for plucking to the *janam* as compared with those for leaving a leaf are not significant.

Average valuation for 4″ and *janam*, and 4″ and leaf	= 14.37*d*.
Average valuation for 8″ and *janam*, and 8″ and leaf	= 14.64*d*.
Average valuation for 4″ and 8″ both to *janam*	= 14.43*d*.
Average valuation for 4″ and 8″ both with a leaf left on the subsequent plucking round	= 14.58*d*.
Significant difference ...	= 0.23*d*.

The difference between the value of the tea from the high and low skiffing is significant and in agreement with the finding of the Calcutta tasters. Thus the two sets of results generally

can be considered to confirm each other satisfactorily in this experiment.

In 1936 no manufacture of leaf from the plucking plots was made. In 1937, the third year of plucking treatment, the first 6 series (plucked at different initial heights (*a*) to janam, and (*b*) subsequently leaving a big leaf once), were manufactured weekly from 4th June to 30th November, 25 times in all.

Series 9 and 10 were manufactured from 4th June to 30th July, during which period they were being plucked to 4″ initial height and to the *janam*.

Series 10 was manufactured weekly for the rest of the season with the exception of the week when it was left unplucked (6th August).

Series 9, left unplucked all August and then skiffed leaving 2 leaves, did not give sufficient leaf for manufacture till 1st October, from which date it was manufactured weekly till the end of the season.

We may thus divide the season's manufacture into three parts :—

(1). Late second flush and early rains (4th June to 30th July).

(2). Rains period (6th August to 24th September).

(3). Autumnal period (1st October to 30th November).

The crops harvested, and value of teas made, are examined below for each of the three periods.

1. *Late Second flush and early Rains period (4th June to 29th July).*

It is unfortunate that there was insufficient leaf for manufacture until the beginning of June, as information on the effect and severity of plucking over the early second flush period, which is thus lost, would have been valuable.

The total crop made over the period 4th June to 30th July, together with average valuations of 6 Calcutta and 8 London tasters, are tabulated below.

Series	Plucking.	Mds. Tea per acre June and July.	Average Valuation.	
			Calcutta	London.
			as. p.	s. d.
1	4″ and to janam	3·52	12—4·6	1—4·3
2	6″ „ „ „	3·59	12—3·8	1—4·3
3	8″ „ „ „	3·29	12—3·9	1—4·3
4	4″ and a leaf	3·58	12—4·7	1—4·4
5	6″ „ „ „	3·39	12—4·4	1—4·3
6	8″ „ „ „	3·04	12—4·4	1—4·3
9	4″ and to janam (*a*)	3·80	12—4·4	1—4·4
10	4″ „ „ „ (*b*)	3·85	12—3·8	1—4·4

(*a*) Unplucked all August in 1936.

(*b*) Unplucked first week of August in 1936.

There is no significant difference between any of the 8 average valuations given by Calcutta or London. Each is the average of 48 independent valuations in the case of Calcutta and 64 in the case of the London averages.

The reports on tip, colour of infused leaf and liquors, strength, quality and briskness of liquors indicate no differences in these characters due to different degrees of severity of plucking. Thus in the late second flush and early rains the forms of plucking giving greatest crop, have given the biggest net return. Up to end of May the 4 series plucked to 4″ initial growth, and the series plucked to 6″ and to the *janam*, gave about ¾ md. tea. The lighter forms of plucking gave about ¼ md. Even supposing that the lighter plucking gave teas worth 6d. a pound more up to the end of May, the harder plucking would still have paid over the whole second flush period. There is nothing however in the reports and valuations of the teas made during

early June, to indicate that lighter plucking might have given any better earlier teas than the harder plucking.

2. *Rains period* (6th August to 24th September).

During this period, series 9 (unplucked during August) was giving either no leaf at all, or so little that there was insufficient for manufacture. Series 10 was missing from the regular weekly manufacture on the 6th August when unplucked. Its average valuation therefore is for the period 13th August to 24th September. The crop obtained from series 10 during August was 1.0 md. tea compared with 2.1 mds. tea from the 4″ *janam* plucking, while in September the crops were 1.4 md. from series 10 and 3.0 mds. from the 4″ *janam* series.

Total crop and average valuations over Rain Period.

Series	Plucking	Mds. Tea per acre Aug. and September	Average Valuations	
			Calcutta	London
			As. P.	s. d.
1	4″ and to janam	4·38	11-10·0	1-4·5
2	6″ „ „ „	4·56	11-10·0	1-4·5
3	8″ „ „ „	4·39	11-10·5	1-4·6
4	4″ and a leaf	4·35	11-10 8	1-4·6
5	6″ „ „ „	4·25	11-11·0	1-4·6
6	8″ „ „ „	4·01	11-11·2	1-4·6
10	Unplucked one week	2·02	11-9·5	1-4·4
	Significant difference	...	0·8 p.	...

The plucking to 4″, 6″ or 8″ initial growth and leaving a leaf the next round has according to Calcutta given "rains" teas which are valued significantly better than 4″ and 6″ initial growth plucked to the *janam*. The teas made after leaving bushes unplucked for one round show up poorly in comparison

with regular plucking. The tea made was very poor for 4 weeks after leaving the area unplucked; it then improved rapidly and the teas made on the 10th, 17th and 24th September were equal to those from the 8″ and a leaf plucking.

The London tasters' averages show no significant differences but the tendency is to confirm the Calcutta tasters' opinion that rains teas from bushes plucked over a leaf on the second round are preferable to those from bushes plucked throughout to the *janam*. Reports of the Calcutta tasters on the different characters of the dry tea and liquors show indications of slightly better quality of liquor in the teas from bushes plucked over a leaf on the second round, compared with bushes plucked throughout to the *janam*. There are no indications of any other differences in leaf or liquor due to variations in severity of plucking.

(3). *Autumnal period* (*1st October to 30th November*).

Throughout this period all 8 series were manufactured weekly.

Total crop and valuations over Autumnal period.

	Mds. Tea per acre October and November	Average valuations	
		Calcutta.	London.
		As. P.	s. d.
4″ to janam	4·34	11—6·5	1—3·40
6″ „ „	4·49	11—6·8	1—3·51
8″ „ „	4·25	11—7·5	1—3·64
4″ and a leaf	4·35	11—7·3	1—3·61
6″ „ „	4·19	11—7·5	1—3·68
8″ „ „	3·89	11—8·6	1—3·80
Unplucked 3 weeks	2·85	11—9·5	1—3·86
„ 1 week	2·72	11—9·5	1—3·78
Significant difference		0·84 pies	0·19 d.

The verdict of the London and Calcutta tasters is that teas made from bushes plucked over a leaf on the second round are better than teas plucked throughout to the *janam*; also that the longer the initial growth, the better the teas.

Calcutta.				London.			
Initial height	Janam plucked	One leaf left once	Average for initial plucking height.	Initial height	Janam plucked	One leaf left once	Average for initial plucking height.
4″	11·6·5	11·7·3	11·6·9	4″	1·3·40	1·3·61	1·3·50
6″	11·6·8	11·7·5	11·7·1	6″	1·3·35	1·3·68	1·3·60
8″	11·7·5	11·8·6	11·8·0	8″	1·3·64	1·3·80	1·3·72
Averages for janam and leaving one leaf	11·6·9	11·7·8	.....	.....	1·3·52	1·3·70	—

All tasters find that the effect of leaving unplucked for 3 weeks or for one week, and then raising the level of plucking by a height corresponding to 2 leaves above the previous plucking level of 4″ has been to produce autumnal teas which are better than those from bushes plucked to an initial height of 4″ or 6″ continuously throughout the season to the *janam*.

The Calcutta tasters also prefer the teas from the bushes on which the plucking level was raised two leaves, to all the other forms of plucking except the 8″ and a leaf.

Examination of the reports on the characters of these autumnal teas indicates that the lighter initial plucking, the leaving of one leaf on the second round, or two leaves in August, increases tip, colour of infusions and liquor, quality and briskness. All teas however are reported on as being equal in strength of liquors.

Pruning and Quality.

Leaf from 8 series of plots pruned during different months in 1936 and 1937 (in six cases clean pruned and two cut across) was manufactured 22 times during the 1937 season.

The pruning treatments were as follows :—

1. Clean pruned in April 1936.
2. Cut across in April 1936.
3. Clean pruned in June 1936.
4. Clean pruned in October 1936.
5. Clean pruned in December 1936.
6. Cut across in December 1936.
7. Clean pruned in January 1937.
8. Clean pruned in February 1937.

The plots pruned in April, June and October 1936 were not pruned during 1937, and thus in the case of the April and June pruned plots, the bushes bore the appearance and gave leaf typical of unpruned tea during the period of manufacture (June to November 1937). Previous to the commencement of manufacture of these 8 series, leaf was available for manufacture from the first four series (April, June and October pruning). These four series only were manufactured on five occasions, from 18th May to 15th June.

The reports of 8 London and 6 Calcutta brokers on the various liquor and leaf characters, together with valuations, were obtained throughout the season on all the teas manufactured. During the early part of the season (18th May to 15th June), when four series only were manufactured, the teas made from the areas pruned in October 1936 were picked out both by London and Calcutta tasters as being decidedly preferable to those from areas pruned in June or April 1936. This preference was greatest on the first occasion of manufacture (18th May) and tended to become less by the middle of June.

The reports from London and Calcutta on the liquor and leaf characteristics, indicated that the October pruning had produced teas with more quality and briskness. The London tasters also found these teas more tippy, and with greater strength of liquor than the June or April pruned teas, but Calcutta tasters reports did not show clearly any marked superiority of the October pruned teas, in these characters. The average valuations for London and Calcutta (and the crop yield) for the period 18th May to 15th June, are given below :—

Pruning	Average valuation		Crop
	Calcutta	London	Mds. tea per acre to end of June
	As. P.	s. d.	
April clean pruned ...	12-7·5	1-3·58	5·29
,, cut across ...	12-8·2	1-3·74	4·75
June clean pruned ...	12-6·6	1-3·71	4·91
October clean pruned ...	13-0·4	1-4·11	2·34
Significant difference ...	2·30 pies	0·33 d.	...

Cleaning out of banjhi and dead wood has had no significant effect on quality, compared with mere cutting across, nor has the difference of 2 months in time of pruning, between the April and June pruned areas.

From the 22nd June to the 16th November the leaf from the 8 series referred to on p. 22 were manufactured weekly. The later pruned areas (those pruned in October and December 1936 and January and February 1937) were generally preferred by

London and Calcutta, to those pruned in April or June 1936, over the whole season, though the differences were at times only slight.

There are again no significant differences in quality due to cleaning out, compared with cutting across, on teas from either the April or December pruned plots, made by Calcutta tasters, London prefer the cleaned out to the cut across on December pruning, and though Calcutta tend to agree, their differences are not significant.

Table II gives average valuations for London and Calcutta tasters for 3 periods of the season, and an average over the whole season.

The chief points of interest are :—

(1). That pruning at the normal time, *i.e.*, December or January, has produced the best teas over the whole season, and during each period of the season, *i.e.*, late second flush, rains and autumn.

(2). That the removal of unproductive shoots—the process referred to as "cleaning out", has, on the December pruning, produced better tea during late second flush than the pruning with no cleaning out (cutting across). The difference is made significant by London tasters, and in the same direction by Calcutta tasters, though not on the level of significance.

(3). That areas pruned in late spring and early rains give poorer teas when unpruned during the following season, than areas pruned at the end of the rains or during the cold weather immediately preceding the season of manufacture.

Averages of 6 Calcutta tasters.

	22nd June to 10th Aug.	17th Aug. to 5th Oct.	28th Sep. to 16th Nov.	Average for season.
	As. P.	As. P.	As. P.	As. P.
April clean	12·2·60	11· 9·81	11· 9·41	11-11·42
April cut across	12·3·02	11·10·02	11· 9·89	11-11·81
June clean	12·2·81	11·10·21	11·10·13	11-11·83
October clean	12·3·99	11·10·19	11·10·43	12· 0·29
December ,, ...	12·4·75	11·11·52	11·10·43	12· 1·06
,, cut across	12·4·42	11·11·35	11·10·78	12· 1·02
January	12·5·15	11·11·04	11·10,51	12· 1·11
Febrnary	12·4·34	11·10·87	11·10·21	12· 0·67
Significant difference	1·36 p.	0·87 p.	0·63 p.	0·58 p.

Averages of 8 London tasters.

	22nd. June to 10th. Aug.	17th. Aug. to 5th. Oct.	28th. Sept. to 16th. Nov.	Average for season
	s. d.	s. d.	s. d.	s. d.
April clean ...	1-4·20	1-3·83	1-4·00	1-4·33
,, cut across ...	1-4·15	1-3·79	1-3·94	1-4·27
June clean ...	1-4·15	1-3·81	1-3·84	1-4·26
October ,, ...	1-4·34	1-3·95	1-4·01	1-4·40
December ,, ...	1-4·40	1-4·12	1·4·13	1-4·54
,, cut across ...	1-4·17	1-3·99	1-4·07	1-4·37
January ...	1-4·32	1-4·01	1-4·08	1-4·46
February ...	1-4·32	1-3·96	1-4·00	1-4·401
Significant difference	0·115d.	0·170 d.	—	0·109d.

Reports on the various characters.

The Calcutta tasters report significantly more and better coloured tip over 1937 second flush and rains teas in the teas from plots pruned in December 1936 or later, than the teas from the plots pruned in October or earlier in 1936.

They find no difference in tip over the autumnal period, nor do they find significant differences in any of the other leaf characters, or any of the liquor characters, at any period of the season.

Measurements of creaming down of the liquors show that "December cut across" teas gave significantly less cream than any other teas. The "April cut across" teas creamed down less than the "April cleaned out" teas but the difference was not so marked as in the case of the December pruning, and was not quite significant.

APPENDIX B.

Miniature Manufactures.

A line of 10 bushes* of which four replicate manufactures were complete at the time of analysis, has been taken as an illustration of the nature of the results. Table I summarises (in the form of marks out of a possible 100) the tasters remarks on quality, strength and briskness and gives also the valuation in pies, and crop as maunds of dry tea per acre for the period of the experiment. With regard to crop it must be remembered that the crop figures, though strictly comparable one with the other, are based on only four pluckings and if one considers the whole of the year with practically nil crop at the beginning and end of the season then these figures will be very much reduced.

* The plot layout is in lines of bushes instead of the more usual blocks.

TABLE I.

Tasters reports on 10 bushes all of the same *jat* (bushes selected to illustrate the magnitude of the difference which may occur within one *jat*.)

Date.	Bush 132.					Bush 133.					Bush 134.					Bush 135.					Bush 136.				
	Quality.	Strength.	Briskness.	Valuation in pies.	Crop.	Quality.	Strength.	Briskness.	Valuation in pies.	Crop.	Quality.	Strength.	Briskness.	Valuation in pies.	Crop.	Quality.	Strength.	Briskness.	Valuation in pies.	Crop.	Quality.	Strength.	Briskness.	Valuation in pies.	Crop.
16.6.	100	40	83	177	9	40	20	50	156	25	40	60	50	159	23	20	20	66	156	18	20	20	50	153	26
8.7.	60	40	66	150	22	20	40	66	144	41	80	20	83	150	28	80	20	66	150	25	0	20	50	138	20
4.8.	40	80	66	150	14	40	60	66	147	33	20	40	50	141	19	80	40	66	156	26	40	40	66	147	27
11.8.	40	80	50	150	9	20	20	33	138	30	40	40	66	141	11	60	40	66	147	18	20	20	50	141	23
	Bush 137					Bush 138					Bush 139					Bush 140					Bush 141				
16.6.	80	40	66	165	18	60	60	66	163	19	20	20	16	153	19	20	20	16	153	20	60	80	66	161	11
28.7.	80	20	83	141	20	100	40	83	162	12	20	40	50	144	20	60	20	66	150	13	100	60	83	168	4
4.8.	80	40	66	162	20	80	40	66	162	19	20	60	66	144	16	40	60	66	147	18	80	80	66	159	17
11.8.	80	40	66	153	23	60	60	50	147	11	20	40	50	141	16	80	40	83	153	20	60	60	66	150	17

Table II.

Analysis of variance of the marks given for "quality" in table I.

	Variance.	Degrees freedom.	Mean Variance.
Bushes	18210	9	2023·33
Dates	1150	3	383·33
Residual	9950	27	368·51
Total	29310	39	...

Table III.

Significance of the differences (in respect of quality) between the bushes in table I.

Bush	132	133	134	135	136	137	138	139	140	141
132	-									
133	<.05	-								
134	<.5	(<.3)	-							
135	Nil	(<.05)	(<.3)	-						
136	<.01	<.5	<.1	<.01	-					
137	(<.2)	(<.01)	(<.02)	(<.2)	(<.01)	-				
138	(<.3)	(<.01)	(<.05)	(<.3)	(<.01)	<.8	-			
139	<.01	<.5	<.1	<.01	Nil	<.01	<.01	-		
140	<.5	(<.2)	(<.8)	<.5	(<.05)	<.05	<.1	(<.05)	-	
141	(<.3)	(<.01)	(<.05)	(<.3)	(<.01)	<.8	Nil	(<.01)	(<.1)	-

Note:—The great similarity of the three bushes 137, 138 and 141 which extends to all the other characteristics *cf.* table I.

Morphologically 137 and 141 are very similar; 138 is a little different.

APPENDIX C.

The Flowering of the Tea Bushh I.

General Morphology and Time Relations.

(1). It has been found that the initiation of flower development begins in an orderly manner dependent upon the periodicity of the terminal bud. The first flush of any shoot shows no visible signs of flower development: visible floral development is initiated at the leaf axils on the first flush only when the terminal bud breaks for the second flush: this order is repeated in subsequent flushes of the same shoot.

(2). The two cataphylls (*janums*) which are thrown off as the terminal bud breaks for a new flush commonly bear a solitary flower in each of their axils. These flowers are visible at the time of unfolding of the cataphylls; whereas no flowers are visible at the axils of the foliage leaves unfolded immediately after the cataphylls until the terminal bud has passed through a period of dormancy and again unfolded the cataphylls of the succeeding flush.

(3). The fifth flush is commonly represented in seed trees in Upper Assam by a slow development of the terminal bud and the shedding of a few cataphylls. Shoots on the tree may make any number of leafy flushes up to four.

(4). After the formation of any flush the terminal bud may remain dormant or may, instead of producing further leafy flushes, pass into the cluster condition. In this, leafy flushes are represented by a very much abbreviated axis, perhaps only a few mm. in length, and the foliage leaves by deciduous cataphylls in the axils of each of which a solitary flower is produced coincident with the unfolding of the cataphyll from the terminal bud. As with leafy flushes, cluster flushes may be clearly demarkated one from the other or may be separated by a region representing periods of only slightly lessened activity. The periodicity of cluster flushes and of leafy flushes on other parts of the bush is the same. The first flush is always leafy. The maximum number of cluster flushes observed on one twig is two (*vide*

para 9): the minimal growth of one terminal bud is one leafy flush followed by dormancy for the rest of the year; maximum growth would be four (or, exceptionally, 5) leafy flushes. All possible intermediates occur.

(5). The relations of the various conditions of floriferousness to seed production is being investigated. Maximum flower does not mean maximum seed: an optimum ratio between leaf and flower is evidently required and this ratio can be altered by cultural conditions.

(6). Flowers at foliage leaf axils are solitary in the axils of the cataphylls of the axillary bud: the axil bud elongates slightly at the time of flower development and forms a dwarf shoot which may bear varying numbers of flowers.

(7). The pedicels of flowers at the axils of the cataphylls which are thrown off by the terminal bud at the beginning of a period of flush are attached directly to the main stem. It will be seen from paras (1) and (2) that flowers at the cataphyll axils of the dwarf shoots of any particular flush and flowers at the cataphyll axils at the base of the succeeding flush develop at the same time. Reference to previous memoranda on flushing will show that the two sets of cataphylls are on homologous flushes. The pedicels of flowers on dwarf shoots are attached to a shoot or branch of a higher order than flowers in the axils of cataphylls at the base of a flush. The pedicels of flowers in a cluster are attached to the same axis as those of flowers in the cataphyll axils at the base of a leafy flush. In the former case the floriferous dwarf shoot is subtended by an assimilating leaf; in the two latter cases the flowers are subtended by deciduous cataphylls. Removal of the leaf subtending the dwarf shoots has a detrimental effect on the set of seed.

(8). Anthesis of flowers on the first flush occurs towards the end (past mid-point) of the development of the third flush of the same terminal bud; anthesis of the second flush flowers occurs towards the end (past mid-point) of the fourth flush. Anthesis of flowers on the third flush occurs during the winter growth

period (5th flush—*vide* para. 3). Anthesis of the fourth flush flowers occurs towards the end of the sixth flush *i.e.* the first flush of the next year. Fourth flush shoots are comparatively rare in mature seed trees of average vigour, so that the spring period of anthesis is often barely discernible or quite absent: only four fourth flush fruits were found in the Tocklai seed bari in 1937 and all these dropped before maturity. Under other conditions, even within the limits of Assam, the spring period of anthesis may be well marked. These factors are confounded with seasonal differences in the development of the flowers themselves, such as arrested development of the stamens and a failure to shed pollen.

(9). Clusters have not been found to represent any flush later than the third flush of the terminal bud so that the spring period of anthesis appears to be entirely confined to flowers on dwarf shoots and in the axils of cataphylls at the bases of leafy flushes, and would appear to be directly dependent upon the vegetative vigour of the bush.

(10). In spite of considerable differences in the time of initiation of floral development and of anthesis, there is no discernible difference in the time of seed fall. Fruits on flushes 1-3 shed their fruits rapidly and over a short period of time commencing with the anthesis of the first flowers on flush 1. From anthesis to seed fall thus occupies, at the most, twelve months: previous to anthesis the flower has passed through at least one and a half flush periods of visible extra-bud development. No first hand data is available for seed fall from the fourth flush (result of the spring or 1st flush period anthesis)—or with regard to the possibility of fifth flush seed (this, if realised, would be the result of anthesis during the second flush period of the year) but a seed grower who experiences a well marked spring anthesis says that all his seed is collected at one time in the autumn and that no seed has been observed to fall in the spring.

(11). Seed from different flushes has passed through comparable stages of development at different rates at different periods of the year.

APPENDIX D.

Bulk Organic Manures.

In previous Annual Reports, details of experiments on tea have been given, comparing the results from cattle manure and green manure cuttings with results from manures supplying nitrogen in purely inorganic forms.

Cattle Manure. Cattle manure at Borbhetta and at Tulsipara continues to produce about the same effect which is obtained from sulphate of ammonia supplying half the quantity of nitrogen per acre. Both these trials have now completed their seventh year. At Halem, cattle manure in the fifth year of application produces a significantly smaller crop than sulphate of ammonia supplying rather less than half as much nitrogen.

The only other published comparison, on tea, of a bulk organic manure with artificials, is reported in the Nyasaland Tea Association Quarterly Journal October 1937.

		Crop in lbs. dry weight of leaf per acre Sept. 1936 to April 1937. 3rd year of annual application
(1)	Kraal manure ... 10 tons Sulphate of potash ... 50 lbs. Superphosphate ... 35 lbs. Sulphate of ammonia ... 100 lbs.	1,116
(2)	Kraal manure ... 10 tons Sulphate of potash ... 50 lbs. Superphosphate ... 35 lbs.	1,008
(3)	Kraal manure ... 10 tons	930
(4)	Sulphate of potash ... 50 lbs. Superphosphate ... 35 lbs. Sulphate of ammonia ... 100 lbs.	796
(5)	Sulphate of potash ... 50 lbs. Superphosphate ... 35 lbs.	736
(6)	No Manure	647
	Significant difference	99

The estimate of error is such that not many of the differences observed are significant. The design of the experiment also is such that we cannot tell whether sulphate of ammonia alone, against no manure, would give the same effect, or less, or more, than sulphate of ammonia with potash and phosphate against potash and phosphate. The omission of a trial of sulphate of ammonia alone is particularly unfortunate in view of results both in North East India and in Ceylon. The quantity of sulphate of ammonia tried, also, is too small, either for use in practice, or for accurate measurement of effect in experiment.

Still the estimated "significant difference" is not much greater than any of the differences in which we are interested and the experiment provides strong indications of great value.

Effect of potash and phosphoric acid.

We can estimate this from 2 comparisons.

$$(5) - (6) = 736 - 647 = 89$$
$$(2) - (3) = 1008 - 930 = 78$$
$$\text{Average} = 84$$

This amount is not statistically significant, but it appears to indicate greater likelihood of effect from either potash or phosphoric acid, or perhaps only from both together, in Nyasaland than in Assam. In East Africa good effect has been observed from sulphur, and the content of sulphur in sulphate of potash and superphosphate possibly might account for the effect observed from them : in that case, it would have been provided as efficiently in the form of sulphate of ammonia.

Effect of Kraal manure.

We can estimate this from 3 comparisons.

$$(3) - (6) = 930 - 647 = 283$$
$$(2) - (5) = 1008 - 736 = 272$$
$$(1) - (4) = 1116 - 796 = 320$$
$$\text{Average} = 292$$

Effect of sulphate of ammonia.

We can estimate this from 2 comparisons.

$$(4) - (5) = 796 - 736 = 60$$
$$(1) - (2) = 1116 - 1008 = 108$$
$$\text{Average} = 84$$

Having regard to the amount of the estimate of error, the various estimates of the effect of any one factor are sufficiently close to show that "interactions" are not very great. Well within experimental error each of the three factors examined acts independently. In Nyasaland, then it is indicated that, on tea, 10 tons Kraal manure give about $\frac{292}{84}$ or nearly 3½ times as much effect as 100 lbs. sulphate of ammonia.

The 100 lbs. sulphate of ammonia would be guaranteed to contain 20.6 lbs. nitrogen. Unfortunately no analysis of the Kraal manure is reported. If the nitrogen in the Kraal manure is as efficient as the nitrogen in Sulphate of ammonia, then the 10 tons Kraal manure would have contained 3½ × 20.6 or about 71 lbs. nitrogen. That is, if the Kraal manure nitrogen was as efficient as the nitrogen in sulphate of ammonia, then the Kraal manure had only about 0.3% nitrogen. It is understood however that Kraal manure is much like our "cattle manure" from cooly lines, and contains normally something like twice as much as .3% nitrogen. If that is so, then Nyasaland finds, as we find in North East India, that their bulk organic manure has something like half the efficiency of sulphate of ammonia per unit of nitrogen.

Of course, as planters, we are more interested in efficiencies for cost. If 10 tons Kraal manure can be put on more cheaply than 350 lbs. sulphate of ammonia, then the Nyasaland results indicate Kraal manure as the better value of the two.

Cattle manure in North East India varies so much in composition that any estimate of its value compared to artificials is only an approximation. If we assume an average content of nitrogen of ½%, then 10 tons contain 112 lbs. nitrogen.

540 lbs. sulphate of ammonia contain as much nitrogen as 10 tons average cattle manure.

540 lbs. sulphate of ammonia can be applied for—

	Rs.	As.	Ps.
Cost in Calcutta @ Rs. 129 per ton ...	31	1	7
Freight @ Rs. 12 per ton ...	2	14	5
Application per acre	0	8	0
Total cost Rs.	34	8	0

This gives us an estimate of about Rs. 3½ per ton as the value of cattle manure, including application, if it is as efficient as sulphate of ammonia per unit of nitrogen. If, as is at present indicated, cattle manure has only about half that efficiency, then we must estimate its value at only about Rs. 1-12-0 per ton, including application. If all costs are charged it cannot generally be applied for so little. This estimate of its value allows nothing for its content of potash or phosphoric acid, or of organic matter, because none of these have any effect of importance on the soils where the comparisons were made. In a much longer time, some or all of them will prove to have a value on some soils at least, so that it is well worth while to make use of all the cattle manure available on a garden, if its cost, applied, does not exceed Rs. 1-12-0 per ton.

In many cases its actual cost to the garden is less, since the cost of collection is fairly chargeable to the cleaning of cooly lines, which must be done in any case; while the whole of the cost is spent on labour only, and the work can be done in slack times when profitable employment of labour, which must be paid, is difficult to find.

Humus Composts. "Humus composts" as made on gardens vary still more in composition, but good samples probably have not much less value than average cattle manure. Since the lowest estimate of the cost of preparation of "humus compost" is about Rs. 2/- per ton at the "compost factory", it

frequently must be the case that applications of "humus compost" do not pay, when application of whatever comes out of the lines would pay, since it has not to bear the extra cost of "manufacture". However, the preparation of humus compost increases the total quantity of bulk manure and may pay where there are ample supplies of raw material close to the tea, and labour is in excess of normal requirements. Each garden must prepare its own careful estimates of cost before deciding on large scale expenditure.

Trials of "humus composts" have progressed less than two years on six commercial gardens (4 in the Surma Valley, two in the Dooars) and also at Borbhetta and at Tocklai.

In 1937, on each of the six commercial gardens the "humus compost" produced no effect on crop.

On four of these, sulphate of ammonia also produced no effect on crop. They were all rich soils, and we must assume that in all these cases circumstances were such that the tea would not take added nitrogen. It is instructive, however, that there was no appearance of effect on crop (or any other observable good character) such as some schools of thought expect from rotted organic matter apart from the nitrogen it supplies.

On the two other commercial gardens where "humus composts" showed no effect, sulphate of ammonia produced great, (and statistically highly significant) effect. On these two gardens then, the "humus compost" failed as a supplier of nitrogen.

At Borbhetta and at Tocklai we obtained small, but statistically significant, effects from humus composts, but they were greatly, and highly significantly, less than from sulphate of ammonia supplying the same quantity of nitrogen.

So far then "humus composts" have not proved very efficient, but judgment must be withheld till experiments have progressed over a much longer time.

Over the past few years 218 samples of "humus composts" have been sent in from gardens as examples of what was being made. As these were all thought to be good examples, their average probably exceeds the average in garden practice. It will be noted that 87% consists of "ash" (mainly ordinary soil) and water.

Number of samples.	Organic matter (loss on ignition) per cent.			Total nitrogen per cent. average.	Ratio Organic matter to nitrogen.
33	Between	6 and 9	average 7·70	0·307	25
66	,,	9 and 12	,, 10·52	0·402	26
59	,,	12 and 15	,, 13·46	0·486	28
30	,,	15 and 18	,, 16·31	0·599	27
28	,,	18 and 21	,, 19·41	0·775	25
7	,,	21 and 24	,, 22·71	0·770	28
General	average		13·01	0·489	26·6

A few samples with over 24% organic matter were sent in described as "humus composts", but all these were unrotted tea-factory wastes with relatively low nitrogen contents in the wet material. Where the nature of the raw material was specified, all samples with much more than 0.5% nitrogen contained large proportions either of tea wastes or of green manure cuttings.

Green manures. At Borbhetta, leafy cuttings of boga medeloa, carried from outside the plots to be manured, produce, in the eighteenth year of continuous application, a crop less, but not significantly less, than is produced by sulphate of ammonia supplying the same quantity of nitrogen; but the large weight of organic matter added, together with the nitrogen as boga medeloa cuttings, has produced no benefit in crop or in any other way which can be observed. Incidentally the crude green boga medeloa cuttings never produced any depression of the tea crop,

even of a temporary nature, nor any sign of "poisoning" effect. On the contrary they acted as rapidly as any efficient artificial.

Experiments on the effect of green crops grown among the tea bushes also yield interesting results. From cowpeas sown in March and hoed in early June, in 1934, and again 1935, we have found no benefit in 1934, 1935, or in 1936 or 1937, compared to similar plots untreated. In the last two years all plots have been unmanured that we might observe residual effects, if any. As we get no effect from the cowpeas we may assume that they fixed no nitrogen from the atmosphere, when hoed in before maturity, and sown on soil relatively rich in available nitrogen (as our soils are in the spring after rain has fallen on soils warmed and dried in the dry "winter" season). We did however hoe in a total of 6 tons organic matter per acre which the untreated check plots did not get. This addition of organic matter has produced no effect whatever.

Boga medeloa sown in alternate lines, and kept lopped for two years, gave loppings, which were buried, containing a total of 180 lbs. nitrogen per acre. While growing, in 1934 and 1935, the boga medeloa produced a small but significant loss of tea crop; but, after the boga medeloa plants were uprooted and removed, gains totalling 5½ mds. tea per acre were observed in 1936 and 1937, and from the appearance of the bushes a further small gain is expected in 1938. The gain however is not much more than was observed from 30 lbs. nitrogen as sulphate of ammonia applied in March 1934 and again in March 1935, but not repeated in 1936 or 1937.

The gain in 1937 from the plots last manured in March 1935 with 145 lbs. sulphate of ammonia per acre, compared to plots never manured, was 0.6 mds. tea per acre, which is statistically significant.

These plots therefore provide no evidence on which we can ascribe a value to the organic matter supplied as about 20,000 lbs. of green cuttings per acre.

Other Organic manures. Trials in several places of sulphate of ammonia against concentrated orgnic manures (horn meal, dried blood, oilcake, sinews and hide) show sulphate of ammonia as a little better than the best organic and much better than most.

Other artificials are not so successful. Nitrate of soda does very well at first, but eventually causes the soil to lose tilth, and bushes then begin to die back in an alarming fashion. This undoubtedly is due to the residue of soda left in the soil. Its bad effect on the tilth of the soil can be neutralized, and the fertility of the soil recovered by the use of sulphate of ammonia. This effect of sulphate of ammonia probably accounts for its success on "bad patches" of soil containing soluble alkali. Calcium cyanamide also does very well at first, but after continuous application its effect becomes less, and this we ascribe to accumulation of lime in the soil, which would be good for many crops, but not for tea. On one set of plots at Borbhetta, calcium cyanamide shows excellent results when applied once in three years, sulphate of ammonia being used in the other two years. Such use left soil acidity unaltered after six years. Continuous cyanamide reduces soil acidity greatly.

Sulphate of ammonia after several years of use increases soil acidity very significantly, and it is to this effect that we ascribe its superiority to other manures on average tea in North East India. Although we have, so far, been unable to produce a soil too acid for tea, even by very large dressings of sulphur, yet very long-continued use of sulphate of ammonia may be found to produce undesirable results in depleting the soil of bases (e.g. potash and lime). To avoid such a possibility we advise the substitution of sulphate of ammonia by cyanamide about once in four years, except on soils found to be insufficiently acid, where sulphate of ammonia alone should be used until soil acidity is satisfactory.

All manures other than sulphate of ammonia either leave soil acidity unaltered or reduce it. Even cattle manure reduces

soil acidity slowly but significantly. If only for this reason, we think some sulphate of ammonia essential for any tea garden.

All our results, to-date, far from finding any benefit from organic manures show sulphate of ammonia to be superior, and the longer the experiments progress the better does sulphate of ammonia show up. In early years it is not better than nitrate of soda, calcium cyanamide, or horn meal, though it is no worse.

Prunings. All these results now quoted have been obtained on tea pruned annually, the prunings being returned to the soil in addition to the manures under trial. The manure under trial therefore was applied together with a considerable quantity of organic matter in the form of prunings.

We have one trial at Borbhetta in which the manure is applied both on top of the prunings and after the prunings have been removed. This has progressed for 3 years only.

In the third year, 1937, prunings against no prunings produced 2½ mds. more tea per acre, whether in presence or absence of sulphate of ammonia. Sulphate of ammonia against no artificial produced 3 mds. more tea per acre, whether in presence or in absence of prunings. Prunings and sulphate of ammonia together produced 5½ mds. per acre more tea than was produced by the plots getting neither sulphate of ammonia nor prunings. The sulphate of ammonia provided annually 40 lbs. nitrogen per acre, while the prunings averaged 60 lbs. Prunings then, so far, are less efficient per unit of nitrogen than sulphate of ammonia, in spite of the bulk of organic matter (1¼ tons dry organic matter annually per acre) provided by the prunings.

On plots yielding 20 mds. tea per acre we do find a temporary depression of tea crop where the heavy mass of prunings is buried, compared to similar plots where prunings are left to rot on the surface. This loss is slightly more than made up later in the season. On the plots under discussion where the best of the four treatments averages about 11 mds. tea per acre

the quantity of "raw" (unfermented) prunings buried has never produced even a temporary depression of tea crop : on the contrary the buried prunings have in each year produced increased tea crop as soon as tea crop became great enough to be measured.

The material provided by annual prunings rots very rapidly, and the resultant humus is incorporated with the soil, even when the system of cultivation is such that they are left unburied on the surface. The heaviest wood is about pencil-thick, and even that disappears within about seven months. Under trees in Assam natural jungle, or under heavily yielding tea not cultivated, we do not find a mat of humus on the surface, but normal mineral soil fairly rich to some depth. Worms are numerous and active in spite of moderately high soil acidity, while other organisms (e.g. crickets and beetles) also carry down organic matter into the soil. On the particular plots under discussion the cultivation usual in Assam is given, so that a "deep" hoe covers the prunings, soon after they fall from the bushes, with about 6" of soil.

Where prunings have been removed, the top 9" of soil has lost 0.2% organic matter, a statistically significant quantity (equivalent to about 6,000 lbs. of dry organic matter per acre) in only 3 years. Where prunings have been buried, the soil organic matter has not lessened, or if it has the loss is too small to be measured.

So far, sulphate of ammonia is just as efficient on soil deprived of organic matter, as on soil receiving prunings.

Three years is a very short time. It is possible, we may even guess it to be probable, that where all organic matter continues to be removed, the soil will lose condition, and sulphate of ammonia may fail to prove efficient. On the plots from which prunings are removed, fallen leaves also are picked up, while cultivation to all plots in this trial is so frequent that practically no weeds grow.

Up to 18 years, however, sulphate of ammonia alone has proved more efficient than any organic manure tried for so long, where prunings also are buried as they are in normal North East Indian practice, and no loss of soil organic matter can be detected.

Where 80 or 120 lbs. nitrogen are applied annually as artificial, the soil organic matter is increasing, presumably because the weights of prunings for annual burial are increased, and the soil is very closely occupied by tea roots.

On annual crops sulphate of ammonia is commonly found to exercise no residual effect: what is not used in the year of application is lost. This is not the case with tea. On tea the effect of a single dressing has been found significant up to 6 years afterwards. With a single large dressing (80 lbs. nitrogen per acre) the effect in the second year may be as great as in the first year. This residual effect must come largely from the increased weight of organic nitrogen added as prunings.

The present evidence on tea therefore provides no indication that we need have any fear of trouble from the use of suitable inorganic manures on tea, so long as prunings are buried. Still 18 years is not a long time in agriculture, and the present evidence is not, by itself, sufficient to make it possible to state that similar results must continue indefinitely.

Long term effects. For evidence on long term effects we must consider laboratory results, and field results on other crops in other climates.

Laboratory results show several factors in favour of a moderately high concentration of organic matter in the soil.

The humus in the soil has about five times the power of clay to hold bases (*e.g.*, ammonia, lime and potash) in a form available to plants but not liable to washing out. The ability of a normal mineral soil to assume "tilth" (the crumbly condition suitable for a seed-bed) under the action of cultivating

implements, is greater in a soil moderately rich in "soil humus" than in a humus-deficient soil. A soil rich in humus will hold more water against evaporation than a soil poor in humus.

In consequence it is not only the farmer or gardener who likes to see a big bulk of manure go on to his land. Soil scientists retain a respect for dung; even when their own experimental plots provide, as is usually the case, no evidence of superior effect compared to artificials, either for the same quantities of plant food or for the same cost.

By many scientists, analogies between plant nutrition and animal nutrition have been assumed, to reinforce a natural tendency to a preference for "natural" manures. It is proved that animals receiving a sufficiency of protein, carbohydrates, and mineral salts, are not properly fed unless they receive also "auxiliary foods" of organic origin which are essential though extremely small quantities are necessary, and are received automatically in a normal mixed diet.

These auxiliary animal foods fall into two classes—

(1). The vitamins, which must form part of the animal's food, and must come generally from outside its own body. The best known example is Vitamin C, deficiency of which causes scurvy.

(2). The hormones, which are produced by the ductless glands within the animal's own body, but have to be provided from outside when the particular gland is not functioning normally. A well-known example is insulin, which should be produced by the pancreas. Its function is to regulate the level of the blood-sugar. A failure of the pancreas to excrete insulin produces diabetes which is relieved by injections of insulin.

Both the vitamins and the hormones are organic chemical compounds. The chemical composition of most of them is known, and many have been prepared in pure crystalline form,

Vitamins. There is no proof that any organic compound, of the nature of a vitamin, is necessary to a green plant from outside sources.

Viswanath has published experiments which he assumes to prove a necessity for vitamin B in the food of a plant, but the differences he reports in favour of cattle manure compared to sulphate of ammonia, are more reasonably to be assigned to the greater quantity of available nitrogen applied in 5 tons dung than in 1 cwt. sulphate of ammonia.

The same objection applies to the work of Rowland and Wilkinson who reported more vitamin B in grass seed grown with 20 loads dung per acre than with 1 cwt. sulphate of ammonia.

Harris (Cambridge) and Schreiner and others (Leipzig) found higher vitamin contents in grain grown with artificials than in grain grown with dung.

Hunt found no relation between vitamin B content and manurial treatment.

The probability is indicated that plants produce more vitamin according as they are better fed, whether the food supplied is organic or inorganic; but the uncertainty, which must always attend the use of single plots for experiment, prevents the formation of any sound conclusion.

Green growing plants are the normal producers of vitamins, and it seems at least highly probable that they can produce all they need from simple inorganic substances, unless suffering from some failure of the organs concerned.

The early work of Bottomley indicated the possibility of the presence of growth-promoting factors other than normal mineral foods, in peat subjected to the action of certain bacteria, in soil extracts, and in the water-soluble extracts of both fresh and rotted dung. Mockeridge found that a substance obtained from sugar solutions, after fermentation by yeast, stimulated the growth of duck-weed growing in water culture, which sup-

ports the idea that useful auxiliary plant foods may be produced during the fermentation of carbohydrates. Repetition and extension of such work, independently, by Clark, Wolfe, Mendiola, and Saeger, not only failed to substantiate the theory of the necessity of organic auxiliary growth factors, but refuted it. This later work however does show that with improperly balanced mixtures of inorganic plant food, organic matter acts as a corrective, and in that manner may assist plant growth.

One manner in which organic matter may exercise this effect is indicated by the work of Olsen and of Buck, Lineweaver, and Horner, who showed that organic matter produced iron in a state readily available to plants, and plants cannot grow without a trace of iron. There is also a possibility that large quantities of organic matter, collected from a big area and applied to a little one, may sometimes supply one of the other minerals, like boron or manganese, which are essential but in very small quantity only.

Auxins. The work of Went, and of Kogl and Haagen Smit, shows conclusively that there are present in the growing plant, substances akin to animal hormones. These have been termed "auxins". They occur mainly in the growing tips of roots and shoots, but also in other materials, particularly in urine. It is not known whether the auxins in urine have all been taken by the animal from the plants eaten, or are partly manufactured by the animal.

The production in plants of three different auxins (auxin "A", auxin "B", and indole-acetic acid) has been conclusively demonstrated. They are relatively simple organic compounds, which have been prepared in pure crystalline form, and their properties demonstrated. It has not been clearly shown that any of these assist a green plant growing on its own roots in a normal mineral soil, when applied to the soil.

Indole-acetic acid however has been shown to increase the number of roots produced by cuttings of certain plants. It does not increase the rate of growth or the vigour of roots: it

merely increases the number of rootlets which start. It is already used in commerce in gardening industries which use cuttings : so also are other synthetic compounds of similar chemical composition not known to occur in nature. With tea cuttings of desirable *jat,* so far, it has proved of little value in inducing rooting, although it induces prolific callus growth. The probability of the necessity of some other uecessary auxiliary root-growth-promoting substance is indicated.

Indole-acetic acid has been shown to be produced during the rotting of vegetable matter, under the influence of all the common soil-bacteria, and soil fungi, tried. The proof of the presence of this substance in cattle manure and in "humus composts" does open possibilities of a value from them, not obtainable from inorganic manures. Further work may prove the presence of others of even more direct value.

Still, we have no reason to suppose that such substances *are not formed when organic matter rots in the soil just as well* as when the rotting takes place before application to the soil. Even assuming animal intervention to be necessary there is plenty of animal life in a normal soil. The slogan "One cannot farm without the animal" has truth, but it has no practical meaning. It is impossible to exclude animals.

The leaving of land under grass. There is however a fairly clear connection between the keeping of stock in a farm and the fertility of its soil.

With high labour costs the cheapest way to feed cows, is to rely largely on grazing or on hay.

The leaving of land under grass allows accumulation of nitrogen and organic matter in soil, particularly where clover forms part of the seeds mixture as it always does. The cultivation of land to remove its cover of vegetation allows the destruction of soil organic matter and loss of nitrogen : that, in fact, is why it is done, to allow the crop to feed on the nitrate allowed to form.

There are areas of land in Britain, relying on large and relatively cheap supplies of dung from town stables, which have been kept under arable cultivation for a very long time. Now that the horse is superseded by the lorry, dung cannot be obtained in sufficient quantity. Loss of fertility has been rapid, and artificials are not fully effective in restoring fertility. It will be observed that such land is "on strike" in spite of huge dressings of dung in the past.

In fact, from our experience of "bheel soils" we may suspect it partly to be because of the dressings of dung in the past. Old bheels with excessive organic matter become too friable, and lose "binding" power, when the only cure (apart from leaving them flooded for a time) is fresh bheel soil.

The British lands which are losing fertility in the absence of dung were largely market gardens, for which coarsely sandy soils usually are chosen for their "earliness" and "warmth". A very large number of soils with a normal content of clay have stood continued arable cultivation without any addition of organic matter, other than the stubble ploughed in, for very long terms of years, and produce good crops so long as they receive artificials.

The amount of "farmyard manure" produced on an ordinary mixed farm is limited, not by the number of animals on the farm, but by the quantity of straw produced. Dairy farms produce relatively little farmyard manure.

The association of soil fertility with animals, therefore, appears to be more closely connected with the consequent introduction of grass into the rotation than with the quantity of dung applied.

Soil condition. A virgin mineral soil newly opened from jungle is in perfect physical condition. This "good condition" we ascribe partly to its accumulation of humus, and partly to its having been left undisturbed, and occupied by plant roots, to the natural forces of alternate wetting and drying, to acquire the desirable "crumb structure."

No crop approximates more closely to jungle conditions than tea, if only it is kept fully occupying the soil; and it is clear that it can be so kept, with the help of its own prunings, if it receives sufficient nitrogen, either from artificials, or from a good cover of leguminous trees. Dangerous times are those when the tea incompletely fills the soil, for some years after planting, and when the tea is cut back. At these times, a cover crop, preferably a legume, should be used to fill up the vacant spaces.

Quality. On the second flush teas of 1935, a fall in quality was observed, assessed at 0.16 pence per lb. for each increment of 40 lbs. artificial nitrogen per acre, while crop increased by 300 lbs. tea per acre for each increment of 40 lbs. nitrogen. This was in the fifth year of continuous annual dressings. Whether this falling off in quality with increasing crop could be avoided or reduced by the substitution of bulk organic manures for artificials is not definitely certain.

In 1933 no difference in quality could be observed by tasters between teas manured with sulphate of ammonia and teas manured with cattle manure, but the plots under comparison had then received only two dressings each.

We do not think it likely that the nature of the manure can make much difference to quality so long as the teas compared come from bushes yielding the same crop, but there is of course a possibility that bulk organic manures might contain some quality-producing substance not present in inorganics. The question is to be investigated again in 1938.

The possibility that increased acidity of the soil, though increasing crop, might reduce quality, also will be investigated in 1938.

In the meantime, we do suspect, from the nature of the growth, some loss in quality for a short period starting about a month after application of artificials, or concentrated organics, and in consequence we advise very early application.